Claims

1. A metallocene compound of formula (I):

$$\begin{array}{c|c}
R^{2} & R^{3} \\
R^{1} & R^{5} \\
R^{8} & R^{8} \\
R^{8} & R^{8}
\end{array}$$
(I)

wherein:

M is an atom of a transition metal selected from those belonging to group 3, 4, 5, 6 or to the lanthanide or actinide groups in the Periodic Table of the Elements;

p is an integer from 0 to 3, being equal to the formal oxidation state of the metal M minus 2;

X, same or different, is a hydrogen atom, a halogen atom, or a R, OR, OSO₂CF₃, OCOR, SR, NR₂ or PR₂ group, wherein R is a C_1 - C_{40} hydrocarbon group optionally containing heteroatoms belonging to groups 13-17 of the Periodic Table of the Elements; or two X can optionally form a substituted or unsubstituted butadienyl radical or a OR'O group wherein R' is a divalent radical selected from C_1 - C_{40} alkylidene, C_6 - C_{40} arylidene, C_7 - C_{40} alkylarylidene and C_7 - C_{40} arylalkylidene radicals;

L is a divalent bridging group selected from C_1 - C_{20} alkylidene, C_3 - C_{20} cycloalkylidene, C_6 - C_{20} arylidene, C_7 - C_{20} alkylarylidene, or C_7 - C_{20} arylalkylidene radicals optionally containing heteroatoms belonging to groups 13-17 of the Periodic Table of the Elements, and a silylidene radical containing up to 5 silicon atoms;

R¹ is a C₁-C₄₀ hydrocarbon group optionally containing heteroatoms belonging to groups 13-17 of the Periodic Table of the Elements;

R³ is a C₁-C₄₀ hydrocarbon group optionally containing heteroatoms belonging to groups 13-17 of the Periodic Table of the Elements;

 R^2 , R^4 and R^5 , equal to or different from each other, are hydrogen atoms or C_1 - C_{40} hydrocarbon groups optionally containing heteroatoms belonging to groups 13-17 of the Periodic Table of the Elements; with the proviso that least one among R^2 , R^4 and R^5 is a hydrogen atom;

R³ with R⁴ and/or R⁴ with R⁵ can also join to form a aliphatic or aromatic 3-7 membered ring optionally containing heteroatoms belonging to groups 13-16 of the Periodic Table of the Elements; said ring can bear one or more hydrocarbon substituents having from 1 to 20 carbon atoms;

R⁶ and R⁷, equal to or different from each other, are hydrogen atoms or C₁-C₄₀ hydrocarbon groups optionally containing heteroatoms belonging to groups 13-17 of the Periodic Table of the Elements;

R⁸, equal to or different from each other, are hydrogen atoms or C₁-C₅₀ hydrocarbon groups optionally containing heteroatoms belonging to groups 13-17 of the Periodic Table of the Elements; two or more R⁸ groups can also join together to form one or more 3-7 membered ring said rings contain at least one heteroatom belonging to groups 13-16 of the Periodic Table of the Elements; said rings can be further substituted with C₁-C₂₀ hydrocarbon groups optionally containing heteroatoms belonging to groups 13-17 of the Periodic Table of the Elements.

- 2. The metallocene compound of formula (I) according to claim 1 wherein M is titanium, zirconium or hafnium; p is 2; R is a linear or branched, cyclic or acyclic, C₁-C₄₀-alkyl, C₂-C₄₀ alkenyl, C₂-C₄₀ alkynyl, C₆-C₄₀-aryl, C₇-C₄₀-alkylaryl or C₇-C₄₀-arylalkyl radicals; optionally containing heteroatoms belonging to groups 13-17 of the Periodic Table of the Elements; X is a hydrogen atom, a halogen atom or a R group; L is a group Z(R")₂ wherein Z is a carbon or a silicon atom, and R" is a linear or branched, cyclic or acyclic, C₁-C₁₀-alkyl, C₂-C₁₀ alkenyl, C₂-C₁₀ alkynyl, C₆-C₁₀-aryl, C₇-C₁₀-alkylaryl or C₇-C₁₀-arylalkyl radicals optionally containing heteroatoms belonging to groups 13-17 of the Periodic Table of the Elements;
- 3. The metallocene compound of formula (I) according to claims 1 or 2 wherein R¹ is a linear or branched, saturated or unsaturated C₁-C₂₀-alkyl radical; R³ is a linear or branched, saturated or unsaturated C₁-C₂₀-alkyl or a C₆-C₄₀-aryl, radical; R², R⁴ and R⁵ are hydrogen atoms; and R⁶ and R⁷ are hydrogen atoms or linear or branched, saturated or unsaturated C₁-C₂₀-alkyl radicals.
- 4. The metallocene compound according to anyone of claims 1-3 having formula (II)

wherein M, X, p, L R¹, R², R³, R⁴, R⁵, R⁶ and R⁷ have the meaning described in claims 1-3;

R¹⁰ is, a hydrogen atom or C₁-C₄₀ hydrocarbon group optionally containing heteroatoms belonging to groups 13-17 of the Periodic Table of the Elements;

R¹¹, R¹², R¹³ and R¹⁴, equal to or different from each other, are hydrogen atoms or C₁-C₄₀ hydrocarbon groups optionally containing heteroatoms belonging to groups 13-17 of the Periodic Table of the Elements; two adjacent R¹¹, R¹², R¹³ and R¹⁴ groups can also join to form a 3-7 membered ring optionally containing heteroatoms belonging to groups 13-16 of the Periodic Table of the Elements; said ring can bear one or more hydrocarbon substituents having from 1 to 20 carbon atoms.

- 5. The metallocene compound according to claim 4 wherein R¹⁰ is a linear or branched C₁-C₂₀-alkyl radical; R¹¹ is a C₆-C₄₀-aryl, C₇-C₄₀-alkylaryl or C₇-C₄₀-arylalkyl radical or form with R¹² a phenyl ring that can be substituted with hydrocarbon groups having from 1 to 20 carbon atoms; R¹² is a hydrogen atoms or form with R¹¹ 3-7 membered ring as explained above; R¹⁴ and R¹³ are hydrogen atoms or C₁-C₂₀ alkyl radicals.
- 6. The metallocene compound according to claims 4 or 5 having formula (III)

$$\begin{array}{c|ccccc}
R^3 & R^4 \\
R^1 & R^5 \\
R^1 & R^7 \\
R^6 & R^7 \\
R^6 & R^7 \\
R^7 & R^6 \\
R^7 & R^6 \\
R^7 & R^6 \\
R^7 & R^6 \\
R^7 & R^7 & R^7 & R^7 & R^7 \\
R^7 & R^7 & R^7 & R^7 & R^7 & R^7 \\
R^7 & R^7 \\
R^7 & R^7$$

(III)

wherein M, X, p, L R¹, R², R³, R⁴, R⁵, R⁶, R⁷, R¹⁰, R¹³ and R¹⁴ have the meaning described in claim 1-5.

7. The metallocene compound according to anyone of claims 1-3 having formula (IV)

wherein M, X, p, L R^1 , R^2 , R^3 , R^4 , R^5 , R^6 and R^7 have the meaning described in claims 1-3; R^{15} and R^{16} , equal to or different from each other, are hydrogen atoms or C_1 - C_{40} hydrocarbon groups optionally containing heteroatoms belonging to groups 13-17 of the Periodic Table of the Elements;

8. The metallocene compound according to claim 7 wherein R¹⁵ and R¹⁶ are linear or branched C₁-C₄₀-alkyl radicals optionally containing heteroatoms belonging to groups 13-17 of the Periodic Table of the Elements.

- 9. A process for preparing a metallocene compound of formula (I) comprising the following steps:
 - (a) contacting the compound of formula (Ia)

and/or its double bond isomers

wherein R¹, R², R³, R⁴, R⁵, R⁶, R⁷, R⁸ and L have the meaning described in claims 1-3 with a base selected from T_jB, TMgT¹, sodium and potassium hydride, metallic sodium and potassium, wherein B is an alkaline or alkali-earth metal; and j is 1 or 2, j being equal to 1 when B is an alkaline metal, preferably lithium, and j being equal to 2 when B is an alkali-earth metal; T is a linear or branched, cyclic or acyclic, C₁-C₂₀-alkyl, C₆-C₂₀-aryl, C₇-C₂₀-alkylaryl or C₇-C₂₀-arylalkyl radical, optionally containing one or more Si or Ge atoms; preferably T is methyl or butyl radical; T¹ is an halogen atom or a group OR" wherein R" is a linear or branched, cyclic or acyclic, C₁-C₄₀-alkyl, C₆-C₄₀-aryl, C₇-C₄₀-alkylaryl or C₇-C₄₀-arylalkyl radical, optionally containing one or more heteroatoms belonging to groups 13-17 of the Periodic Table of the Elements; wherein the molar ratio between said base and the ligand of the formula (Ia) and is at least 2:1; excess of said base can be used; and

b) contacting the product obtained in step a) with a compound of formula MX_{p+2} wherein M, X and p have the meaning described in claims 1-3.

10. A ligand of formula (Ia)

$$R^{1}$$
 R^{2}
 R^{3}
 R^{4}
 R^{5}
 R^{6}
 R^{8}
 R^{8}
 R^{8}
 R^{8}
 R^{8}
(Ia)

and/or its double bond isomers

wherein R¹, R², R³, R⁴, R⁵, R⁶, R⁷, R⁸ and L have the meaning described in claims 1-3.

11. The ligand according to claim 12 having formulas (IIa), (IIIa) and (IVa) and/or their double bonds isomers

wherein L, R¹, R², R³ R⁴, R⁵, R⁶, R⁷, R⁸, R⁹, R¹⁰, R¹¹, R¹², R¹³, R¹⁴, R¹⁵ and R¹⁶, have been described in claims 1-8.

- 12. A catalyst system obtainable by contacting:
 - a) at least a metallocene compound of formula (I);
 - b) at least an alumoxane or a compound able to form an alkylmetallocene cation; and
 - c) optionally an organo aluminum compound.
- 13. The catalyst system according to claim 12 wherein the metallocene compound of point a) is selected from the compounds of formulas (II), (III) and (IV).
- 14. A process for (co)polymerizing olefins containing from 2 to 20 carbon atoms comprising contacting one or more of said olefins under polymerization conditions in the presence of the catalyst system of claims 12 and 13.
- 15. The process according to claim 14 wherein the olefins are alpha-olefins containing from 2 to 20 carbon atoms.
- 16. The process according to claim 16 wherein are propylene, ethylene or 1-butene are (co)polymerizated